

Claims

1. An apparatus comprising:
 - a circuit board having apertures;
 - separate magnetic flux paths each forming a closed loop that passes through at least one of the apertures and surrounds an interior space, the flux paths including portions that lie within magnetically permeable core pieces, at least two of the flux paths being oriented so that there is a straight line in the circuit board that passes through the interior spaces of the two flux paths without passing through any of the apertures that are included in the paths,
 - an electrically conductive primary winding having a first segment that passes through the interior spaces of the permeable paths and a second segment located outside of the interior spaces; and
 - two or more electrically conductive secondary windings.
2. The apparatus of claim 1 in which the two flux paths are adjacent on the board.
3. The apparatus of claim 1 in which the primary winding comprises a loop.
4. The apparatus of claim 3 in which the loop comprises two longer parallel straight segments and two shorter bridging segments that connect the two longer parallel straight segments.
5. The apparatus of claim 3 in which at least one of the secondary windings is on a second layer of the circuit board.
6. The apparatus of claim 1 in which each of the secondary windings comprises a first segment that passes through fewer interior spaces than does the primary winding.
7. The apparatus of claim 1 in which each of the secondary windings comprises a first segment that overlays a first segment of the primary winding and a second segment that overlays a second segment of the primary winding.
8. The apparatus of claim 1 in which the flux path comprises no gaps between permeable core pieces.
9. The apparatus of claim 1 in which the flux path comprises gaps between permeable core pieces.

10. The apparatus of claim 1 in which the magnetically permeable core pieces include flat pieces and pieces with legs.

11. The apparatus of claim 1 in which at least two of the secondary windings are connected in parallel.

12. The apparatus of claim 1 in which connections to the primary winding are made along an edge of the circuit board that is on a different side of the apparatus from an edge along which connections are made to at least one of the secondary windings.

13. The apparatus of claim 1 in which the core pieces include flat pieces and pieces that each have one leg on one side of an interior space and two legs on another side of the interior space.

14. The apparatus of claim 1 in which the secondary windings are connected to form a single center-tapped winding.

15. The apparatus of claim 1 in which the secondary windings lie on two different layers of the board.

16. The apparatus of claim 1 in which the secondary windings are configured to produce different turns ratios.

17. An apparatus comprising:

a circuit board having apertures;

separate magnetic flux paths each forming a closed loop that passes through at least one of the apertures and surrounds an interior space, the flux paths comprising portions that lie within magnetically permeable core pieces, at least two adjacent ones of the flux paths being oriented so that there is a straight line in the circuit board that passes through the interior spaces of the two flux paths without passing through any of the apertures that are included in the paths,

an electrically conductive primary winding in the form of a loop having a first segment that passes through the interior spaces of the permeable paths and a second segment located outside of the interior spaces; and

two or more electrically conductive secondary windings on at least a second layer of the circuit board, each of the secondary windings comprising a first segment that passes through fewer interior spaces than does the primary winding, each of the secondary windings comprises a first segment that overlays a first segment of the primary

winding and a second segment that overlays a second segment of the primary winding, at least two of the secondary windings connected in parallel,

connections to the primary winding being made along an edge of the circuit board that is on a different side of the apparatus from an edge along which connections are made to at least one of the secondary windings.

18. The apparatus of claim 17 in which the secondary windings are connected to form a single center-tapped winding.

19. The apparatus of claim 17 in which the secondary windings lie on two different layers of the board.

20. The apparatus of claim 17 in which the secondary windings are configured to produce different turns ratios.

21. A circuit comprising:

electrical elements forming a series-resonant full-bridge converter, the elements including a transformer comprising

a circuit board having apertures;

separate magnetic flux paths each forming a closed loop that passes through at least one of the apertures and surrounds an interior space, the flux paths comprising portions that lie within magnetically permeable core pieces, at least two of the flux paths being oriented so that there is a straight line in the circuit board that passes through the interior spaces of the two flux paths without passing through any of the apertures that are included in the paths,

an electrically conductive primary winding having a first segment that passes through the interior spaces of the permeable paths and a second segment located outside of the interior spaces; and

two or more electrically conductive secondary windings.